Fig.1

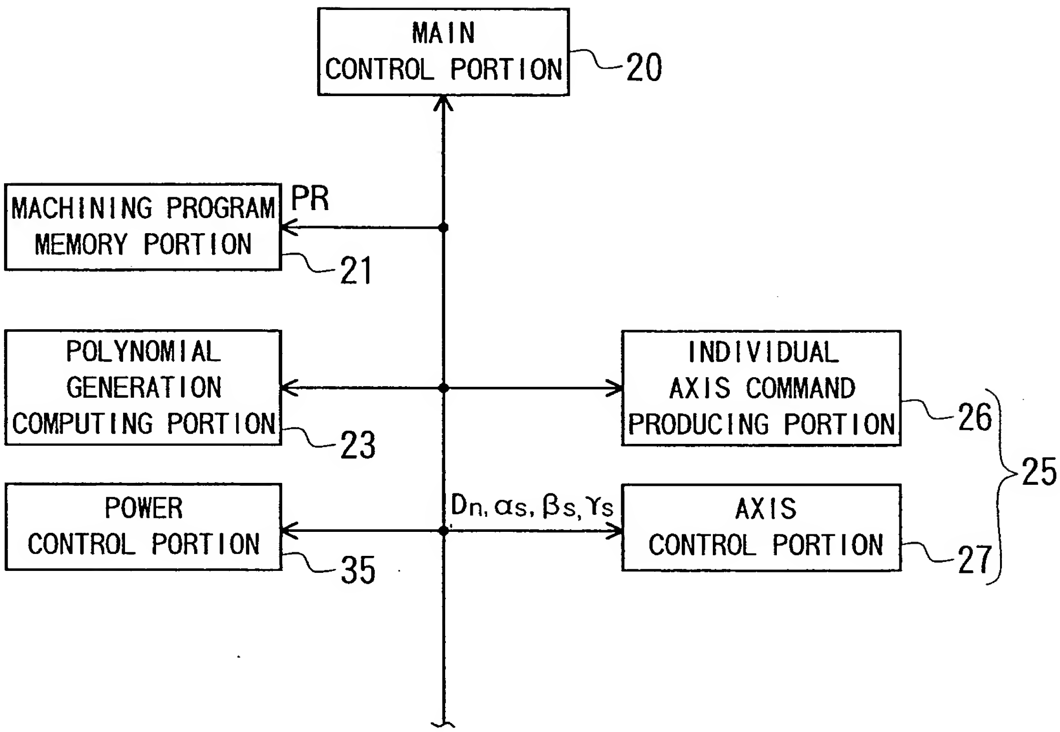

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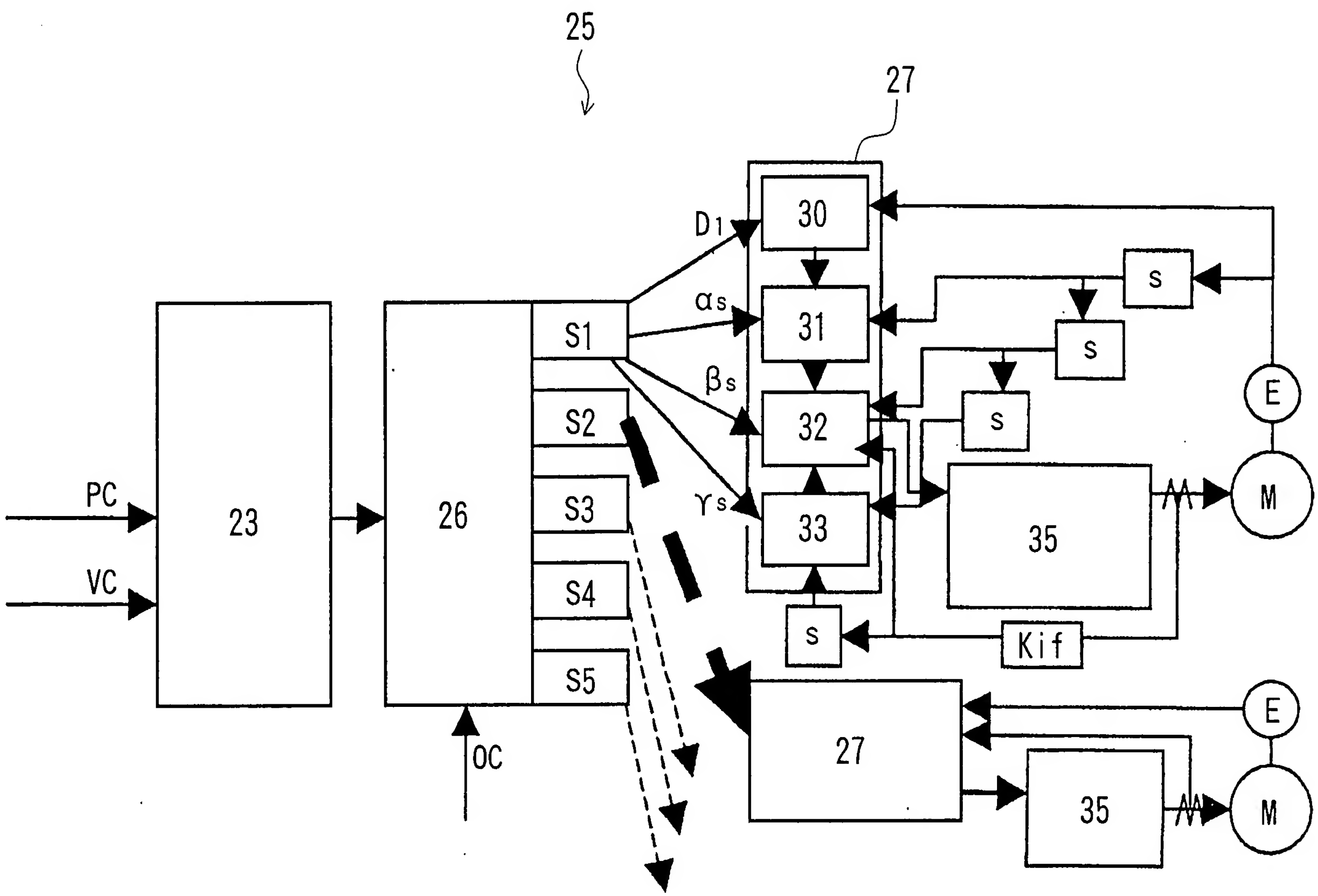
Fig.2



25
27
PC
VC
23
26
OC
S1
S2
S3
S4
S5
D1
αs
βs
γs
30
31
32
33
s
s
s
s
35
Kif
E
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27
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E
M

Fig.3

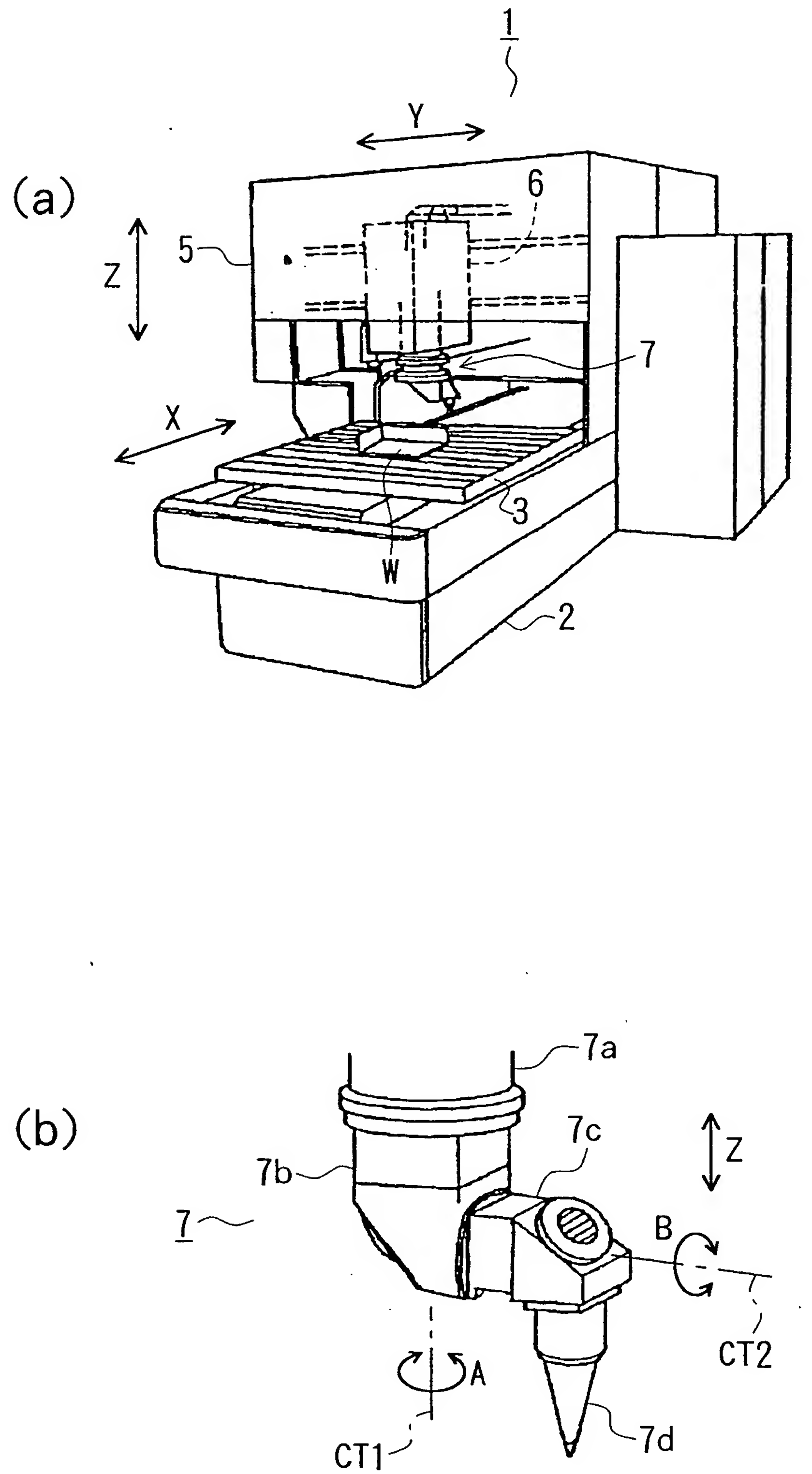


Fig.4

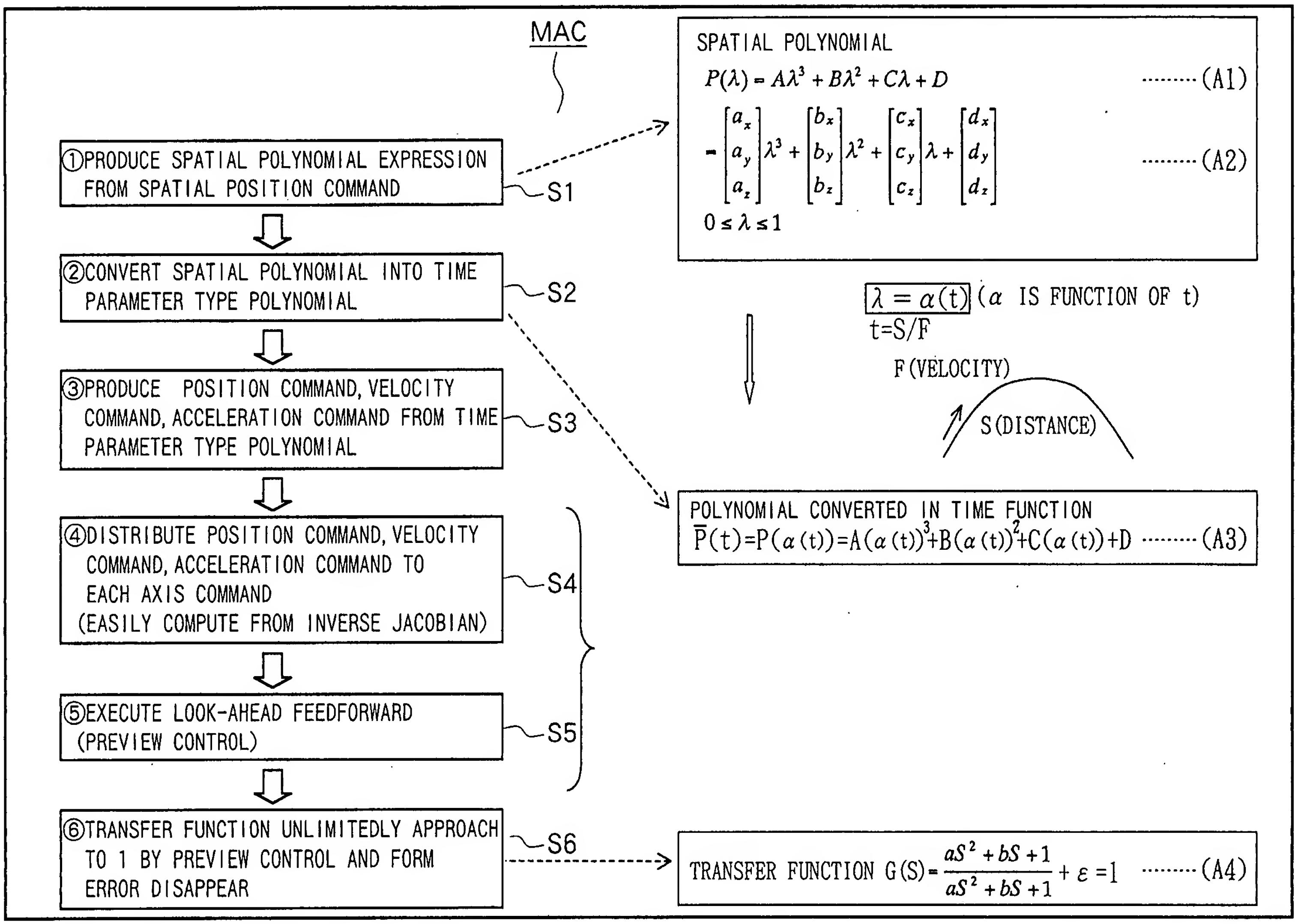
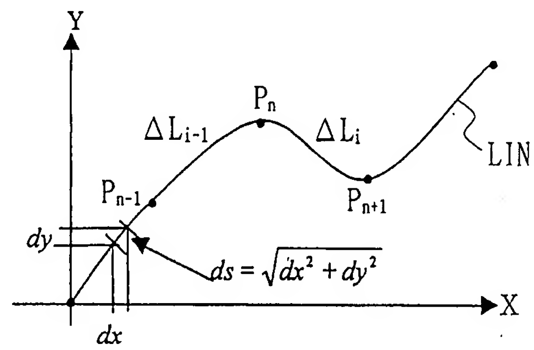

MAC
①PRODUCE SPATIAL POLYNOMIAL EXPRESSION FROM SPATIAL POSITION COMMAND
S1
②CONVERT SPATIAL POLYNOMIAL INTO TIME PARAMETER TYPE POLYNOMIAL
S2
③PRODUCE POSITION COMMAND, VELOCITY COMMAND, ACCELERATION COMMAND FROM TIME PARAMETER TYPE POLYNOMIAL
S3
④DISTRIBUTE POSITION COMMAND, VELOCITY COMMAND, ACCELERATION COMMAND TO EACH AXIS COMMAND (EASILY COMPUTE FROM INVERSE JACOBIAN)
S4
⑤EXECUTE LOOK-AHEAD FEEDFORWARD (PREVIEW CONTROL)
S5
⑥TRANSFER FUNCTION UNLIMITEDLY APPROACH TO 1 BY PREVIEW CONTROL AND FORM ERROR DISAPPEAR
S6
SPATIAL POLYNOMIAL
$P(\lambda) = A\lambda^3 + B\lambda^2 + C\lambda + D$ ……… (A1)
$= \begin{bmatrix} a_x \\ a_y \\ a_z \end{bmatrix}\lambda^3 + \begin{bmatrix} b_x \\ b_y \\ b_z \end{bmatrix}\lambda^2 + \begin{bmatrix} c_x \\ c_y \\ c_z \end{bmatrix}\lambda + \begin{bmatrix} d_x \\ d_y \\ d_z \end{bmatrix}$ ……… (A2)
$0 \leq \lambda \leq 1$
$\boxed{\lambda = \alpha(t)}$ (α IS FUNCTION OF t)
t=S/F
F (VELOCITY)
S (DISTANCE)
POLYNOMIAL CONVERTED IN TIME FUNCTION
$\overline{P}(t)=P(\alpha(t))=A(\alpha(t))^3+B(\alpha(t))^2+C(\alpha(t))+D$ ……… (A3)
TRANSFER FUNCTION $G(S)=\frac{aS^2+bS+1}{aS^2+bS+1}+\varepsilon=1$ ……… (A4)

Fig.5



IF LEFT DRAWING IS CURVED LINE DEFINED BY FOLLOWING POLYNOMIAL,

$$y = f(\lambda) = A\lambda^3 + B\lambda^2 + C\lambda + D \quad \cdots\cdots\cdots (B1)$$

$$x = g(\lambda)$$

$$\text{IF } 0 \leqq \lambda \leqq 1 \quad \cdots\cdots\cdots (B2)$$

IF WHOLE LENGTH OF CURVED LINE DEFINED IS L, FOLLOWING EXPRESSION CAN BE COMPUTED

$$L = \int_0^L ds = \int_0^L \sqrt{dx^2 + dy^2} = \int_0^1 \sqrt{\left(\frac{dx}{d\lambda}\right)^2 + \left(\frac{dy}{d\lambda}\right)^2} \cdot d\lambda \quad \cdots\cdots\cdots (B3)$$

FURTHERMORE, FOLLOWING LINE ELEMENT IS DEFINED BY CUTTING PARAMETER λ WITH SEQUENCE $0 = \lambda_0 < \lambda_1, \lambda_2, \cdots, \lambda_i, \cdots < \lambda_n = 1$

$$\Delta L_i = \int_0^{\lambda_i} \sqrt{\left(\frac{dx}{d\lambda}\right)^2 + \left(\frac{dy}{d\lambda}\right)^2} \cdot d\lambda \quad \cdots\cdots\cdots (B4)$$

GIVE VELOCITY PROFILE OF VELOCITY FUNCTION F(t) HAVING TIME PARAMETER t ON THIS CORVED LINE AND OBTAIN FOLLOWING EXPRESSION

$$\Delta L_i = \int_0^{t_i} F(t) \cdot dt \quad \cdots\cdots\cdots (B5)$$

λ AND t CAN BE RELATED WITH EACH OTHER BY MAKING LENGTH OF THIS LINE SEGMENT EQUAL TO LENGTH OF LINE SEGMENT (1)

$$\Delta L_i = \int_0^{\lambda_i} \sqrt{\left(\frac{dx}{d\lambda}\right)^2 + \left(\frac{dy}{d\lambda}\right)^2} \cdot d\lambda = \int_0^{t_i} F(t) \cdot dt$$

BY SOLVING THIS, FOLLOWING IS COMPUTED

$$\lambda = \alpha(t) \quad \cdots\cdots\cdots (B6)$$

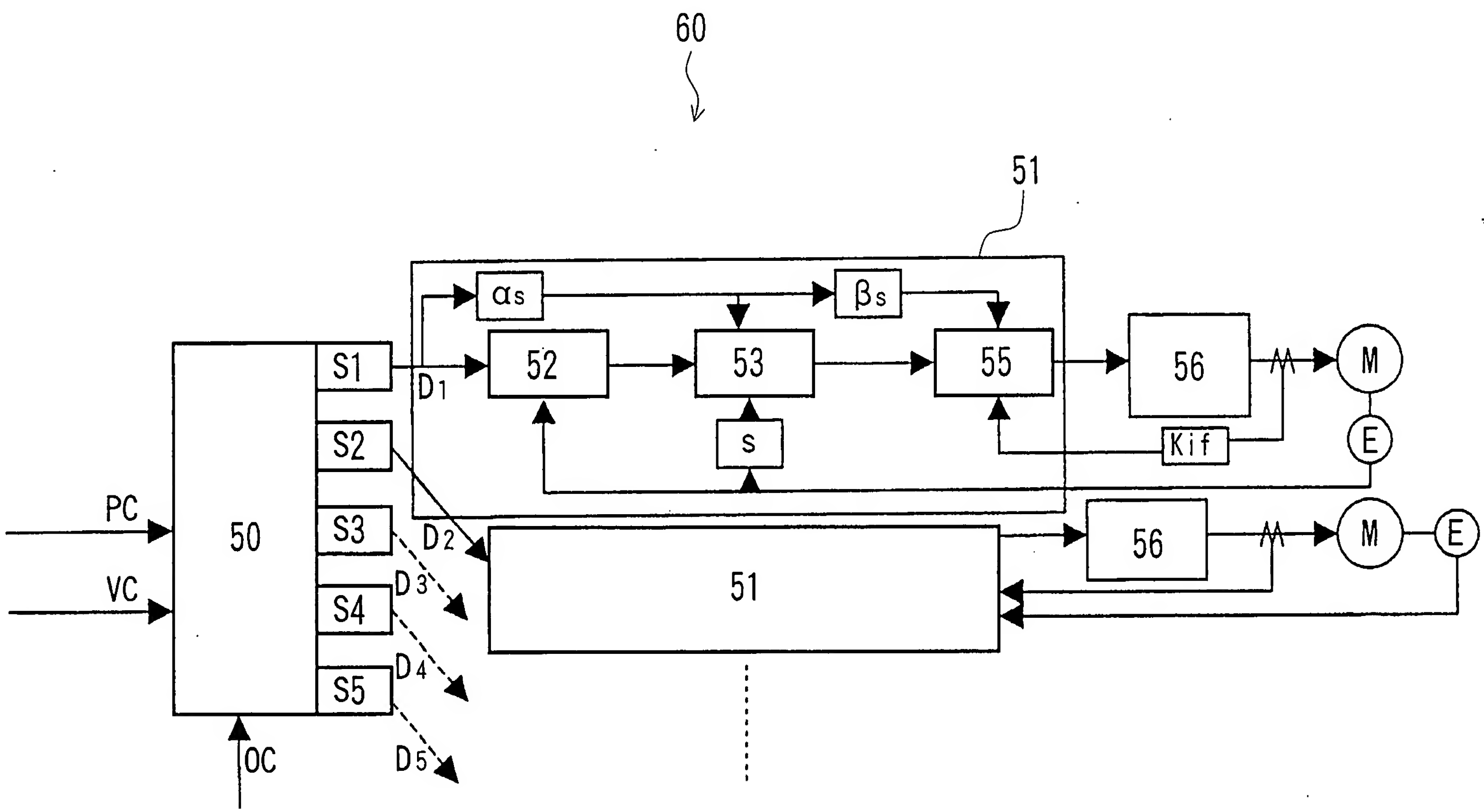
Fig.6

WORKING SPATIAL POSITION OF EACH AXIS CAN BE OBTAINED AS TIME FUNCTION BY $y=f(\alpha(t)), x=g(\alpha(t))$ FROM EXPESSION (3)

THEN, CONVERSION FROM WORKING SPACE OF EACH AXIS INTO JOINT SPACE CAN BE OBTAINED BY FOLLOWING RELATION

WORKING SPACE		CONVERSION		JOINT SPACE
$[\ x=g(\alpha(t)),\ \ y=f\ (\alpha(t))]$	$\Rightarrow$	INVERSE KINEMATICS	$\Rightarrow$	$[X, Y, A, B]$
$\downarrow$				
$[\dot{x}, \dot{y}]$	$\Rightarrow$	INVERSE JACOBIAN	$\Rightarrow$	$[\dot{X}, \dot{Y}, \dot{A}, \dot{B}]$
$\downarrow$				
$[\ddot{x}, \ddot{y}]$	$\Rightarrow$	INVERSE JACOBIAN	$\Rightarrow$	$[\ddot{X}, \ddot{Y}, \ddot{A}, \ddot{B}]$

Fig.7


60
51
50
PC
VC
OC
S1
S2
S3
S4
S5
D1
D2
D3
D4
D5
αs
βs
52
53
55
s
56
Kif
M
E
51
56
M
E